GENERAL GEOLOGY AND SEDIMENTOLOGY OF PASIR TENGKORAK BEACH, MACHINCHANG FORMATION, LANGKAWI, NORTHWEST MALAYSIA.

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PETROLEUM GEOSCIENCE

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by:

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ABSTRACT

Machinchang Formation (Cambrian time) in Langkawi is the oldest rock formation in Peninsular Malaysia that is abundantly exposed at some parts of the island. It is divisible into three members; Hulor Member, Chinchin Member and Jemurok Member. This paper focuses on the outcrop found on the Tengkorak Bed from Tengkorak Beach which belongs to Chincin Member. The objective is to describe and interpret the sedimentary facies of found on Tengkorak Beach outcrop by doing sedimentary logging and petrography studies. Tengkorak beach (±200m thick) has a coarsening upward succession and consists of five sedimentary facies which are thick-bedded blocky sandstone, medium to thick planar cross-bedded sandstone, medium to thick horizontal planar laminated sandstone, medium thick-bedded siltstone and thin beds of mudstone. Pasir Tengkorak beach outcrop is sandier towards the top possibly due to increase in sediment input and the effect of sea level change. Petrography studies show that most of sandstone contains very fine to medium quartz grain size with some iron oxide minerals. The minerals generally are medium sorted and have subangular shape. Overall, outcrops in this area are thought to be deposited in deltaic environments ranging from river mouth to lower prodelta zone.

Keyword: Machinchang Formation, Tengkorak Bed, sedimentary logging, coarsening upward succession, five sedimentary facies, petrography, quartzite sandstone, deltaic environment.

CHAPTER 1: INTRODUCTION

1.1 Background

Machinchang Formation is the name of a rock formation located in Langkawi, Kedah, northwest of Peninsular Malaysia. According to a Paleozoic stratigraphy chart done by geologists, Machinchang Formation is placed within Cambrian time. To be specific, it is in upper Cambrian period, similar with Jerai Formation, a formation that can be found in central Kedah (Foo,1983; Lee,1983). In the Langkawi islands, tectonic deformation separates the Lower and Upper Paleozoic rocks (Koopmans, 1965).

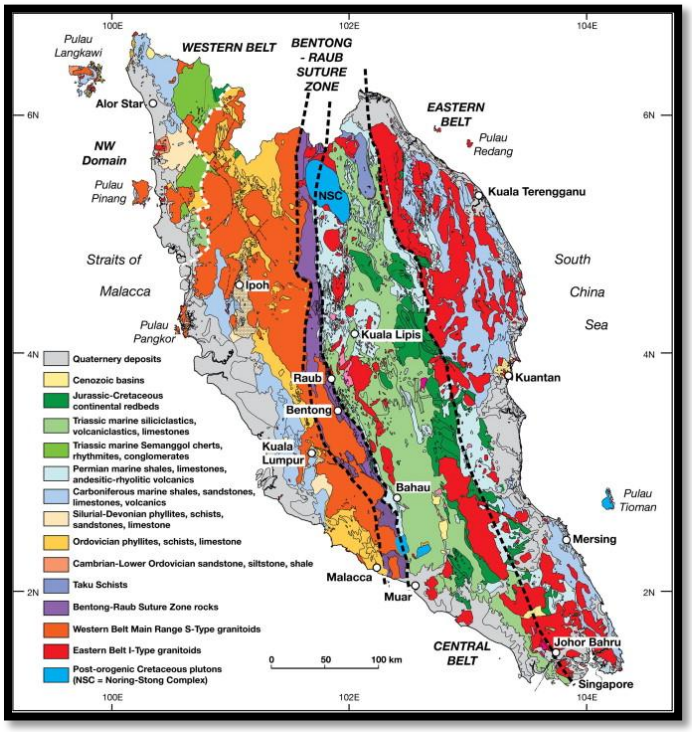


Figure 1: Western belt, Central belt and Eastern belt of Peninsula Malaysia

Machinchang Formation, based on the chart is overlain by a limestone Formation called Setul Formation. Machinchang Formation is a quartzose formation. Madon et. al (1991), verifies this theory where in his research he states that " The Machinchang strata are succeeded, probably conformably, by shallow-marine Setul Limestone and clastic intervals" (pg. 164) (refer Table 2)

Machinchang Formation is divisible into three members; Hulor Member the oldest (>1260m thick), Chinchin Member (>1575m thick), Jemurok Member (>420m thick). Chinchin member is further divided into three beds, the lowest Anak Datai bed (575m thick), Temurun bed (340m thick) and Tengkorak bed (>200m thick) (refer Table 2).

According to Lee (2006), the overall sequence belongs to a highly destructive, wave-influenced delta deposits with a series of preserved beach-ride complexes. Clastic sedimentation was reduced by peneplation of the source area as shown by the finer and thinner beds that grade into limestone of the overlying Ordovician Setul Formation.
This paper will try to define Machinchang Formation in terms of sedimentology to get better understanding about the formation.

1.2 Problem Statement

Machinchang Formation is abundantly exposed and as result, geologists found it accessible and effective for Cambrian rock study. It was first studied by Jones (1981) at localities in Perlis, North Kedah and Langkawi islands. Although many studies have been carried out, they are not many that specify the study on Tengkorak Bed in Pasir Tengkorak.

Other than that, the latest interpretation and study on Pasir Tengkorak was in 2006 by Lee which was 8 years ago. Since then, weathering processes might have altered the outcrop and due to that, this study will try to re-describe the outcrop of Tengkorak Bed of Machinchang Formation. Another problem arises as to answer what is the general geology of the outcrop at Pasir Tengkorak Beach.

1.3 Objectives and Scope of Study

The main objective of this research is to integrate and verify the paleoenvironment and stratigraphic sequence of Tengkorak Bed of Machinchang Formation at Pasir Tengkorak Beach by implementing sedimentology studies and analysis.

Specific objectives are:

1. Describe and interpret the sedimentary facies of Tengkorak Bed of Machinchang Formation by doing sedimentary logging and petrography.
2. To describe and document the facies and facies succession.
3. Identify facies associations in terms of sedimentary processes and relate it to depositional environments.
4. Prepare geological maps to describe the Tengkorak Bed of Machinchang Formation

Scope of study:

This project focuses on the sedimentology of Tengkorak Bed within Chinchin member of Machinchang Formation that can be found in Pasir Tengkorak Beach. Among studies done throughout the project are:

1. Doing facies analysis through sedimentary logging and relate it with depositional environment
2. Petrography studies to identify minerals and look for information regarding the outcrop through microscopic scale.

CHAPTER 2: LITERATURE REVIEW AND THEORY

2.1 Geologic setting

Paleozoic rocks cover about 25% of the Peninsula Malaysia. The Peninsula in details is subdivided into three belts which, characterized by different stratigraphy; Western Belt, Central Belt and Eastern Belt.

Northwest depocentre, which lies in the western belt, is the oldest sedimentary rocks comprise the middle Cambrian to lower Ordovician and only known from this depocentre. (Madon et. al., 1991). The rock mentioned in the Machinchang Formation in Langkawi Island and an equivalent unit in the Gunung Jerai area. Apart from that, there is also an adjacent of Machinchang that lies in Thailand, the Tarutao Formation located approximately five kilometers away. (Foo,1983; Lee, 1983).

Focusing on the west depocentre, it contains extensive Silurian to Permian limestone in the Kinta valley which elsewhere the lower Paleozoic limestone and metasediments are separated by an angular conformity. The most complete sequence of Paleozoic sedimentary rocks can be found exposed in the Northwestern Domain, in Langkawi, Kedah and Perlis. The extension of Paleozoic rocks of Western Belt is distributed from the Malaysian-Thai border southwards to Malacca. According to Lee (1983), the Northwest domain consists of the clastic upper Cambrian Machinchang Formation succeeded by carbonates and detritals bands of the Ordovician to Lower Devonian Setul Formation. This sequence is then followed by clastics of the Upper Devonian or Carboniferous to Lower Permian Kubang Pasu and Singa Formation. A study by Jones (1973) points out that the ancient landmass that had supplied the sediment was located at the west and the basin deepened going to the east where it became more argillaceous.

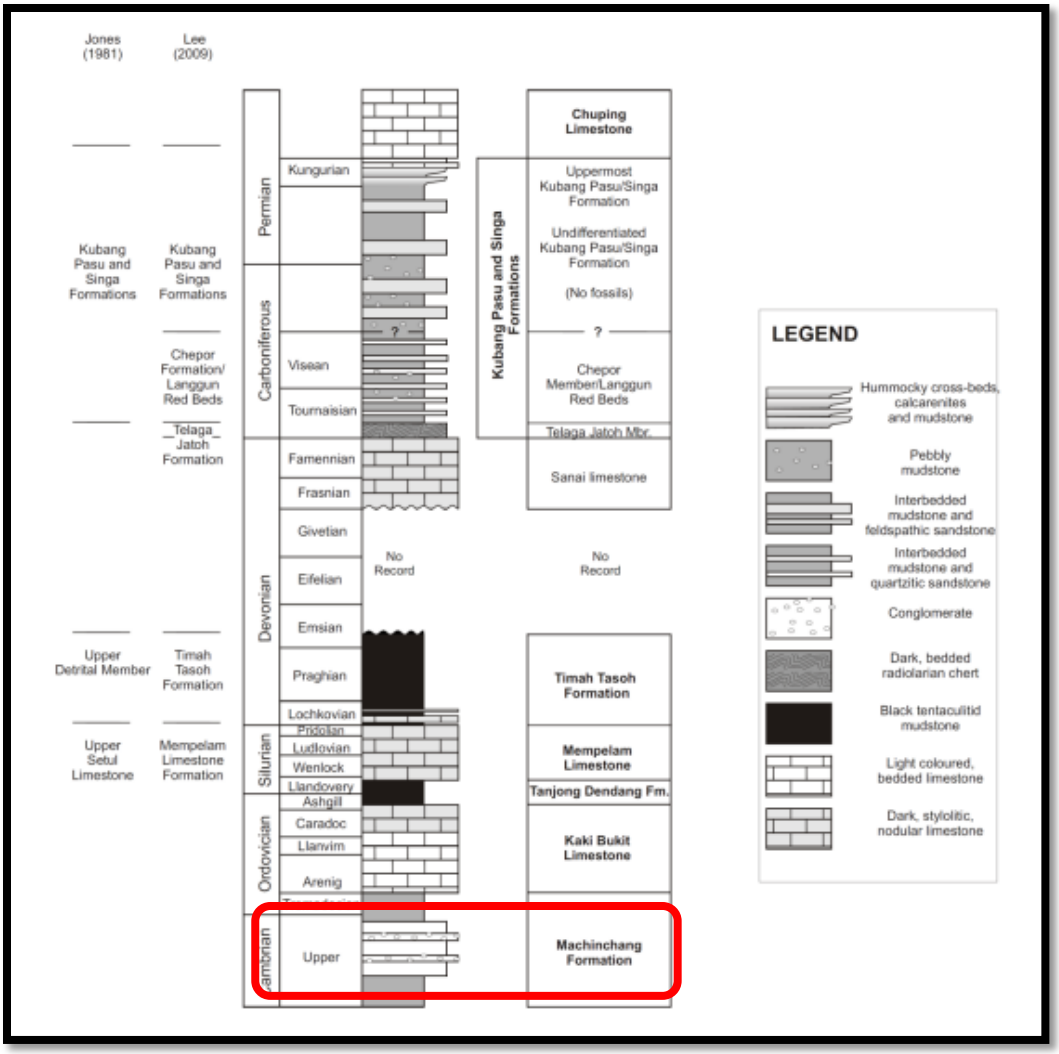


Table 1: Paleozoic Stratigraphy of Northwest Peninsular Malaysia (Meor et al., 2013)

2.2 Machinchang Formation

Lee (1983, 2004) pointed out that Machichang Formation and Tarutoa Formation, its Thai equivalent were informally subdivided into three members with the middle member divisible into three submembers. The depositional environment is prograding shorelines or prodelta deposits where sands had built outwards over finer shelf sediments. The combination of facies observed in this formation supports deltaic interpretation (Miall, 1979, p.47) where he proposes seven characteristics to help recognizing ancient deltas. Five out of seven apply to Machinchang Formation and in addition, Coleman and

Gagliano (1965) also suggest that the gravity induced slumps in the Hulor member are also a common feature of deltas. Precisely, according to Lee (2006)

> The overall Machinchang Formation succession is a coarsening-upwards succession consisting of fine off-shore prodelta siltstone and claystone overlain by a generally fining upwards sequence of estuarine channel-fills, barrier beaches and back barrier open lagoonal to storm influenced shoreface deposits of a high destructive, wave- influential delta.

Lee (2006) has pointed out that the composite stratigraphy of the Machinchang Formation and has described all members and submembers mentioned on the above. Here are the findings:

2.2.1 Hulor Member

Hulor member is the oldest sedimentary rock of Machichang Formation, it has thickness of more than 1260m thick exposed in the core of Machinchang Anticline around Datai Bay (refer Fig. 1). The lithology of Hulor member is sandstone, siltstone and shale succession. The Hulor member is thought to be a coarsening upward succession of rhythmically interlayered grader siltstone and phyllitic mudstone interbedded with thicker bedded clayey sandstone. The research also found that there are four facies that can be distinguished within this member, they are:

i) Mm to cm interbedded rhythmite deposits of light brown siltstone grading into dark grey mudstone
ii) Cm to dm bedded fine argillaceous sandstones that cut erosively into the rhythmites of the first facies
iii) Slumped, very thick, poorly bedded to massive fine argillaceous sandstone
iv) 5m thick interval of black carbonaceous and pyritiferous silty shale indicative of reducing conditions found adjacent to the slumped facies.

2.2.2 Chinchin Member

Chinchin is thought to have more than 1575m thickness and is located at the extreme northwest of the Machinchang area. It is a fining upward succession of subangular quartzose conglomerate to very fine sandstones and can be subdivided into three beds.

i) **Anak Datai Bed:** the lowest, 575m thick and is made up of coarse-grained facies interbedded with a fine-grained facies. The course facies consists of graded lenticular beds of abundantly cross-bedded pebbly sandstone and conglomerate.

ii) **Temurun Bed:** 300m thick and is characterized by a wavy-bedded sequence of thin to thick, wavy-bedded fine sandstone facies with minor graded pebbly sandstone, fine tuffaceous and thin argillaceous intercalations. Myrow et al. (2004) has described that this bed seems to have similar origin to the buckled bedded facies from the Upper Cambrian to Lower Ordovician strata of the Snowy Range Formation is northern Wyoming and sounthern Montana.

iii) **Tengkorak Bed:** the top bed with more than 200m thick is dominated by fine to very fine, thick bedded sandstone facies with less prominent think to thick intervals of fine rippled sandstone, acid tuff and mudstone.

2.2.3 Jemurok Member

The youngest of Machinchang Formation has thickness more than 420m. three facies were distinguished, they are:

i) Cm to dm thick bedded mudstone locally accompanied by thin lenses and streaks of rippled siltstone or very fine sandstone.

ii) Thin to thick bedded very fine sandstone and siltstone, parallel lamination, low angle planar cross bedding and hummocky cross bedding. There were also some trace fossils observed in this facies such as Dictyodora and Chondrites.

iii) Thin wedging beds and lenses of impure limestone.

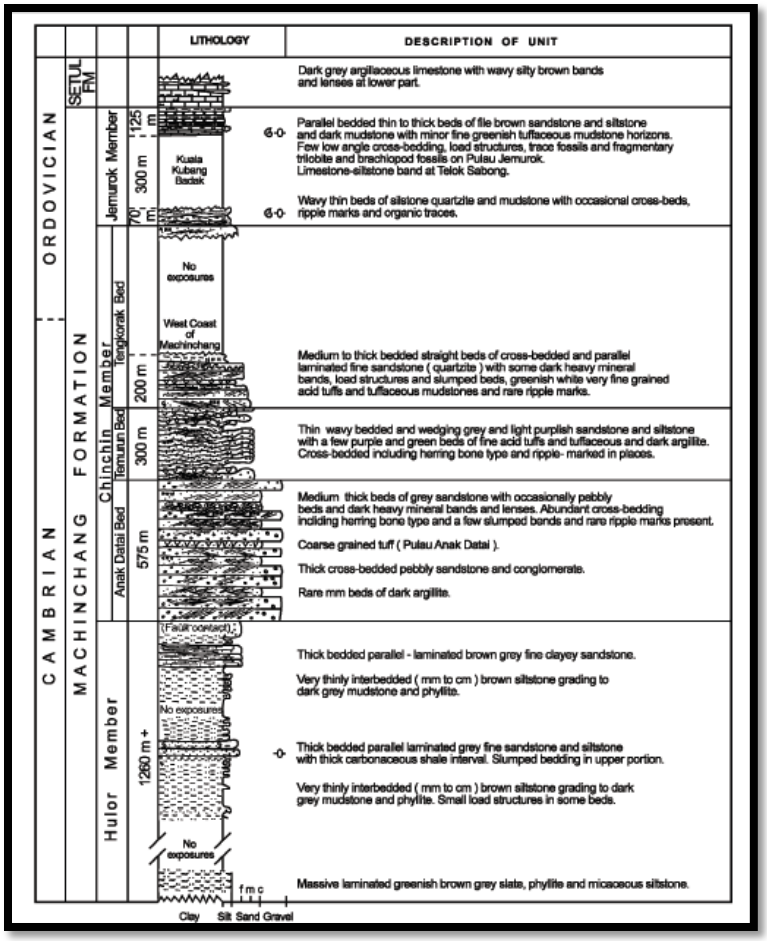


Table 2: Stratigraphy of the Machinchang Formation (after Lee, 2006)

2.3 Paleontological evidence

Lee (2006) has reported that there are more fossils found in Tarutao Formation than in Langkawi. However, these are some fossils observed in Langkawi: *Trilobites, Saukia? Saukioides? Acontheus, Eosaukia, Brachiopod?* and all of these fossils helped in determining the age of Machinchang Formation, which is Late Cambrian. Rowland and Hicks (2005) concluded that the beds of Machinchang Formation were deposited in the lower part of lower Cambrian.Therefore, although the finding initially placed Machinchang in lower Cambrian, it was not strong enough to counter the earlier theory of Machinchang deposited in late Cambrian.

CHAPTER 3: METHODOLOGY/ PROJECT WORK

3.1: Methodology

3.1.1 Field Methodology

Tengkorak Beach is accessible by road connecting main roads in Langkawi Island. It is located at the northern part of the island. The Tengkorak Bed outcrop is just next to the right side of the main attraction, the beach. Objective during field visit are:

- Observation

Observation needs to be made in order to guess or measure the extension of the outcrop. Quick observations at the outcrop to look for potential hazard in this case slippery rocks or dangerous rock slab in order to prevent HSE issues. Observation is also important for field planning on which area to cover first and to avoid poor time management

- Data and sample collection

Data like strike and slip reading were taken in order to construct geological map. In addition, GPS coordinate (***6.429644N, 99.727449E or +6° 25' 46.72"N, +99° 43' 38.82"E)*** was also recorded. Other than that, sketching of the outcrop was also made to better understand the outcrop for future references. Furthermore, sedimentary logging which is the main agenda of this project was also carried out during the visit. Sedimentary logging was done for the most part of the visit together with rock sample collection which would be brought back to laboratory for analysis.

3.1.2 Laboratory Analysis

For this project, the samples taken are mostly of sandstone and mudstone. The laboratory analysis done is petrography which concerns of the detailed descriptions of rocks. For this analysis, the aim is to identify, understand and interpret the mineral content in order to predict the origin of the rock.

3.2 Mapping

As one of the requirements, geological mapping was also done to complete the final year project. For this purpose, this paper will describe the geology of outcrops found along Jalan Anak Datai on the northwestern part of the Langkawi island. This includes the Tengkorak Bed, Anak Datai Bed and Temurun Bed which can be found exposed alongside the main road.

Figure 2:The white box indicates the zone of interest on northwest of Langkawi Island

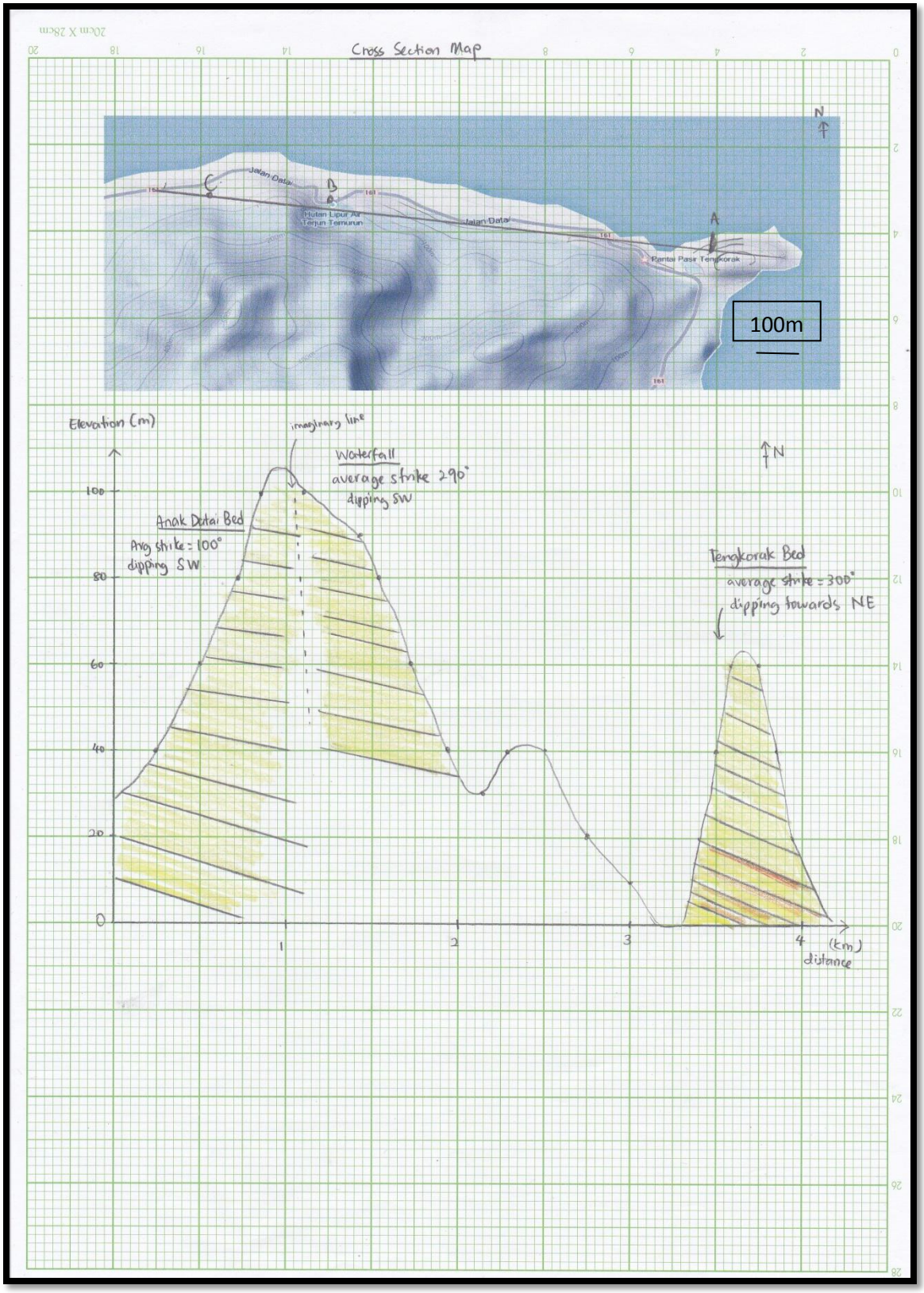


Figure 3: Cross-section map of outcrops around Datai area, northwest of Langkawi

Other than the outcrop in Tengkorak Bed, I also used outcrop data of Anak Datai Bed and Temurun Bed as locations. The Google Terrain map could aid in giving information about the elevation or topography of the location. From the map, the elevation value is extracted and geologic information obtained at outcrops is integrated in the map.

Interpretation of the Cross Section Map of 3 outcrops in Northern Langkawi.

The map covers 3.7km of length and has maximum elevation of 130m from sea level. The map consists of 3 visited outcrops including the project area Pasir Tengkorak, Temurun Waterfall and an outcrop at Anak Datai roadside. For Tengkorak Bed, the measured strikes have been averaged and the value is 300° and is dipping towards NE. The second location in Temurun Water has average strike reading of 290° and is dipping towards SW, while the third location in Anak Datai outcrop which has average strike of 100° and dips towards SW. Looking at the map, all three bedding has consistent dip and strike structure.

As for the lithology, outcrops in these three locations are of the same member which is Chinchin. However, the first location in Pasir Tengkorak is recognized as Tengkorak Bed while the Temurun Waterfall and Anak Datai roadside are probably from Temurun Bed and Anak Datai Bed respectively. Anak Datai Bed is the oldest of the three beds in Chinchin member with Temurun Bed overlying it and Tengkorak Bed the youngest.

According to research done by Lee (1983, 2004), Chinchin member is made up of fining upward succession of subangular quartzose conglomerate to very fine sandstone. This is supported by the visit where it was observed that Anak Datai Bed has rather thick bed succession measuring 40cm while Temurun Bed and Tengkorak Bed are much thinner and Tengkorak Bed especially has interbedding of mudstone and fine grained sandstone.

Geological Map of Pasir Tengkorak beach

At Pasir Tengkorak, the outcrops are classified into four regions based on the bedding plane and locations. Below is the geological map of Pasir Tengkorak beach.

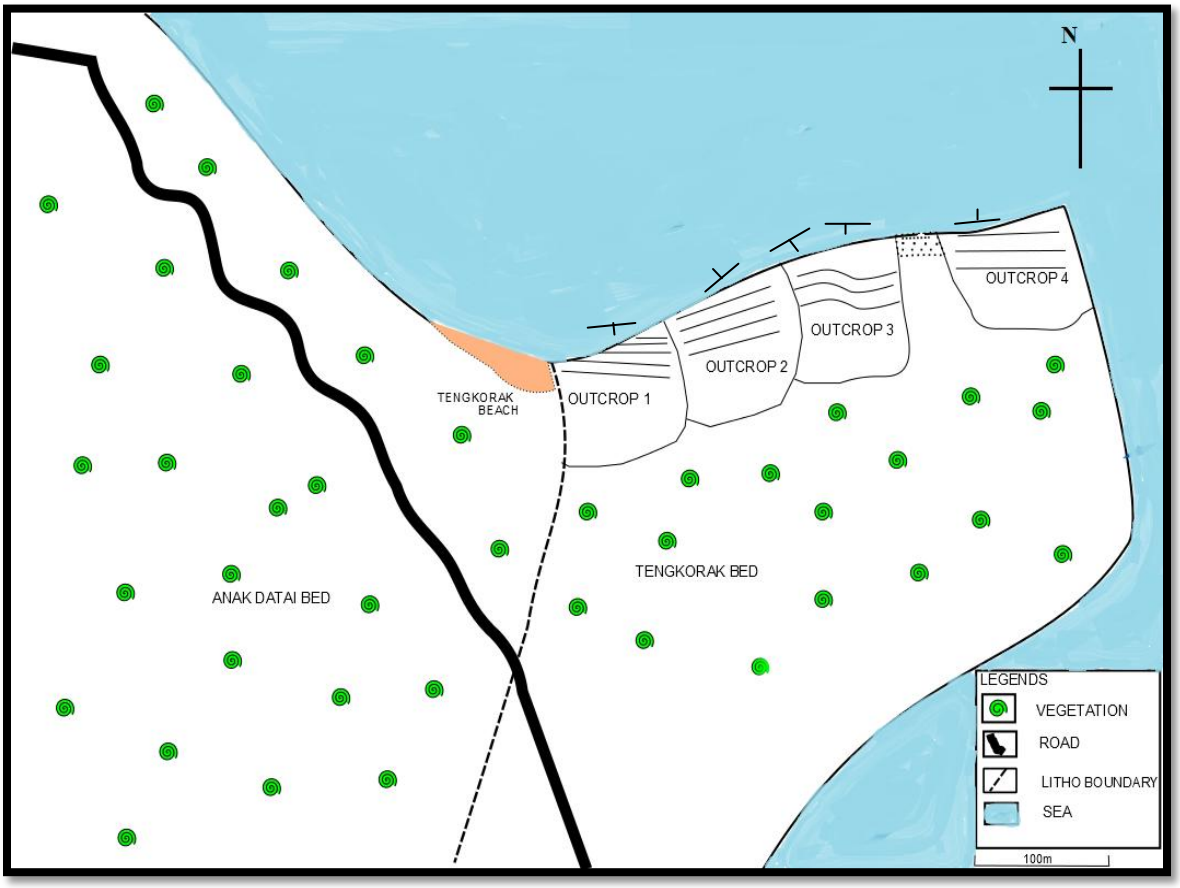
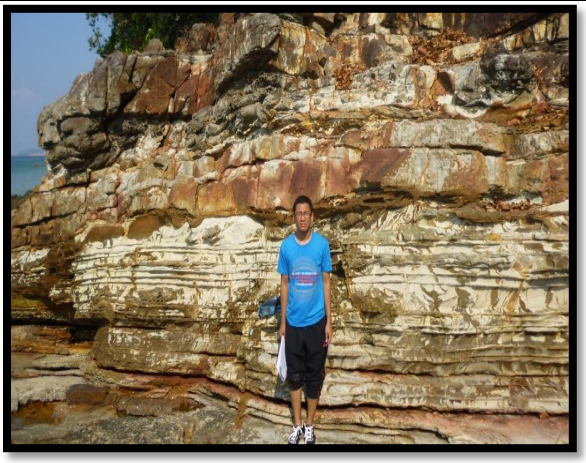


Figure 4: Geological map of Pasir Tengkorak beach.

The map focuses mainly on the outcrops that can be found along the rocky shoreline which extends up to 300 meters. All of the outcrops are within Tengkorak Bed while the western part of the map consists of Anak Datai Bed. Pasir Tengkorak beach is a popular tourist destination, which is situated just beside the Outcrop 1. Outcrop 2 and Outcrop 3 are also situated next to each other while Outcrop 4 is separated by 50 meters of pebbly beach from Outcrop 3.

During field visit, strike/dip reading was taken and it is noted that each of these outcrops yield different readings. Below is the tabulated average data of strike/dip reading:

<table>
<tr>
<td> 
Strike/Dip: 283º/10º
Outcrop 1 has near horizontal bedding. The lower part is dominated by thinly-bedded mudstone intercalated with siltstone followed by medium-thick blocks of sandstone.</td>
<td> 
Strike/Dip: 300º/19º
Outcrop 2 is slightly tilted. It consists of mainly medium-thick sandstone bedding. No presence of mudstone was found here.</td>
</tr>
<tr>
<td> 
Strike/Dip: 92º/50º – 170º/40º
Outcrop 3 has wavy-like bedding showing plastic deformation. Rocks here are sandstone and siltstone with very little thin beds of mudstone.</td>
<td> 
Strike/Dip: 87º/2º
Outcrop 4 consists of only medium-thick sandstone bedding. Horizontal planar lamination and planar cross bedding can be found in abundance here.</td>
</tr>
</table>

3.2.1 Sedimentary Logging

Sedimentary logging represents sedimentary rocks as a series of layers. It is constructed with the x-axis representing grain size and the y-axis representing the distance from a reference point. The layers might not necessarily be horizontal; it can also be vertical as is in this study and the aim is to understand the depositional environment as well as interpreting other geological attributes. In this paper, the logs are classified into having four outcrops, as shown in Figure 7.

The log key of the sedimentary logs is as stated below:

Notes:

- ✓ The scale of the logs is continuous from Outcrop 1 till Outcrop 4.

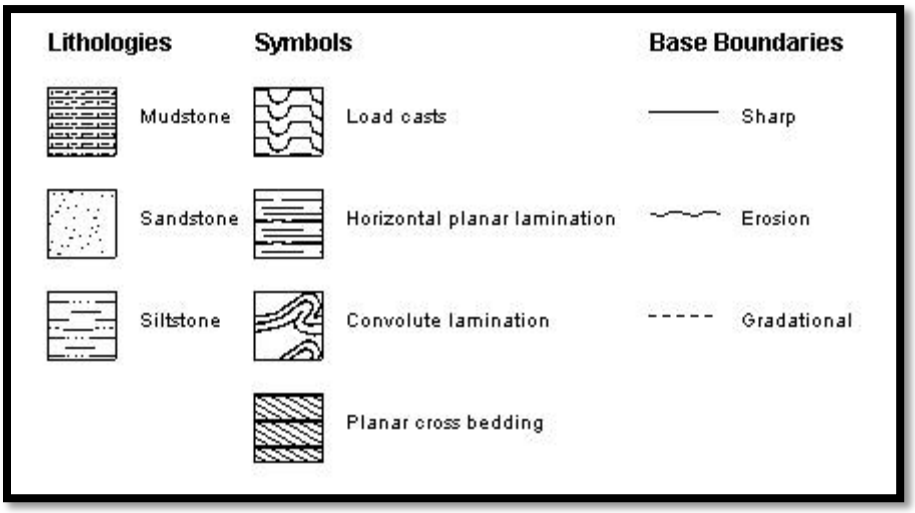
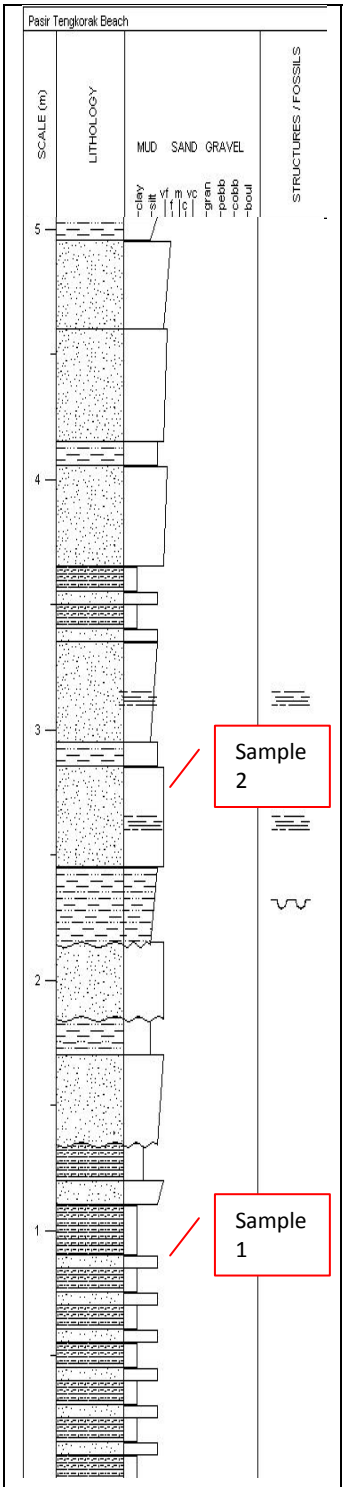


Table 4: Table above shows the log key of sedimentary log

Outcrop 1



DESCRIPTION

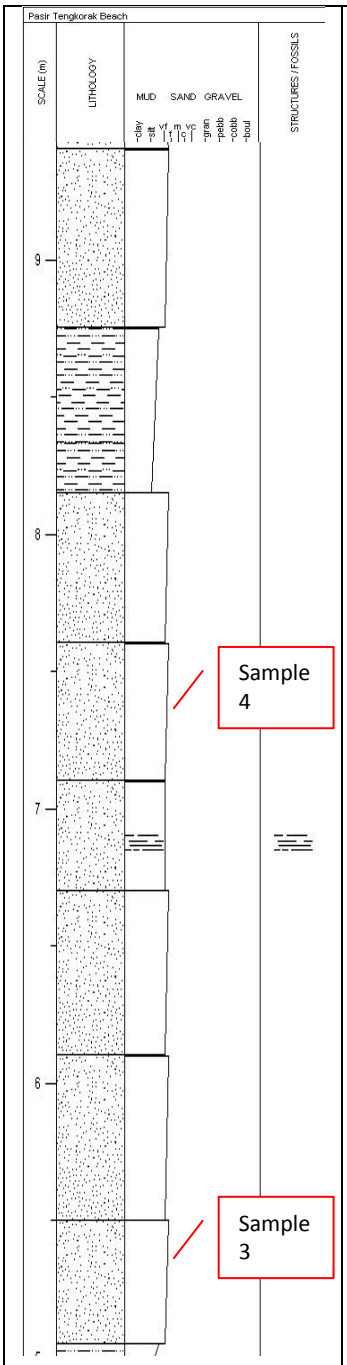
From 2.5m onwards, horizontal planar lamination is seen on two beds

Picture shows thin lenses of sandstone suspended in mudstone bed. This structure is found extensively within the bed

Mudstone beds thicken going upward, less interbedding occurs. Undulating/uneven at the base of mudstone beds.

Interbedding between mudstone and siltstone.

All beds are separated by sharp or flat contacts in between beds



DESCRIPTION

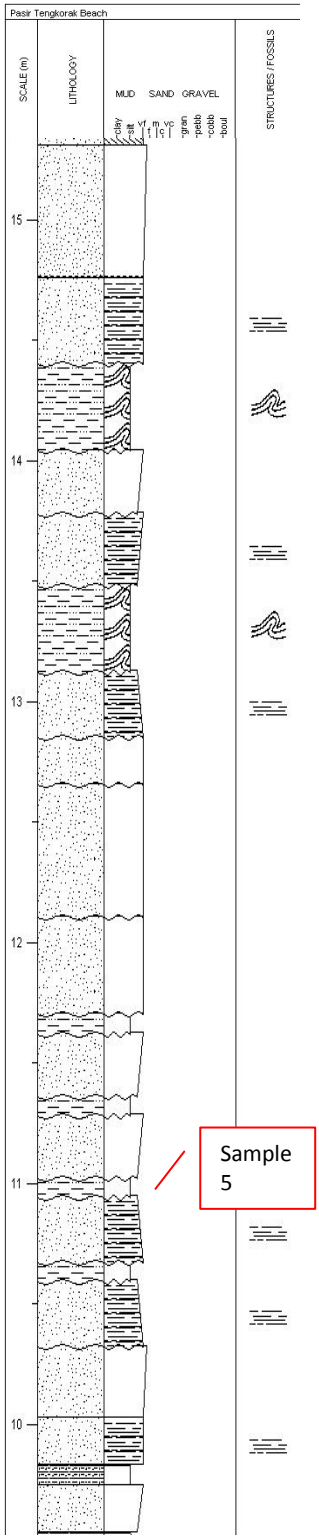
Silty sandstone interbedded with blocky sandstone for about 3 meters thick

Medium-thick blocky sandstone beds dominate the succession. There is a horizontal planar lamination bed at 7m thick.

Interbedding of medium – thick blocky sandstone with thin beds of horizontal planar lamination

All beds are separated by sharp or flat contacts in between beds

Outcrop 2



Thick siltstone bed is succeeded by blocky sandstone.

Presence of thin lenses of sandstone in siltstone, laterally extensive along the bed

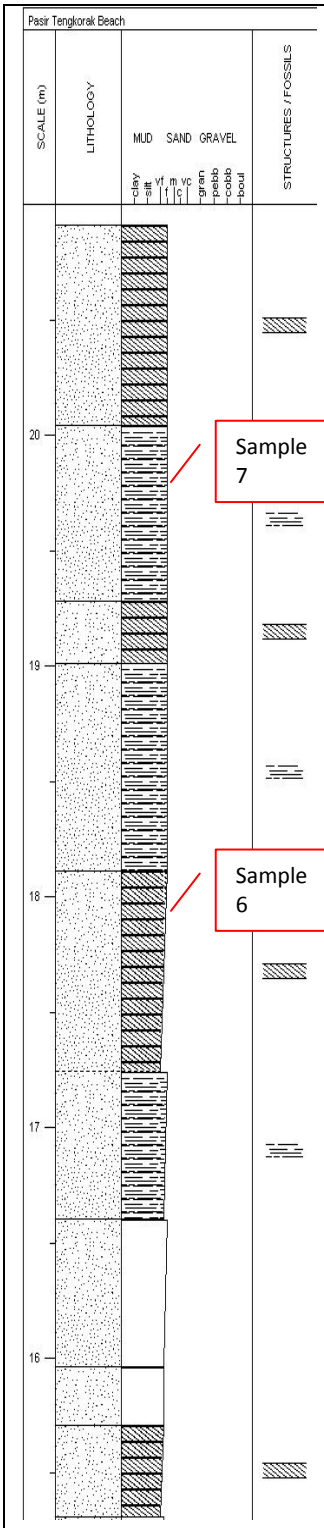
Blocky sandstone interbedded with thin (about 5cm) of mudstone

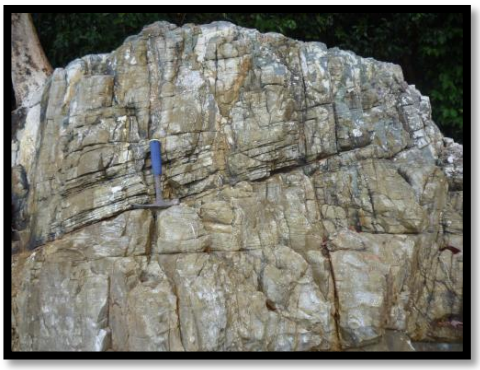
Medium-thick blocky sandstone beds with occasional occurrence of horizontal planar beds interbedded with very thin layer of siltstone.

At this outcrop, the beds have undulating or wavy-like contact surface in between beds

Outcrop 3

Outcrop 4





DESCRIPTION

Layers of horizontal planar bed and planar cross beds occur at the visible top of outcrop

Thin layer of planar crossbed sandwiched in between thick horizontal planar beds

Thin layer of horizontal planar bed cutting across thick planar cross bed at 30°. Thicker set of parallel bed.

Top of parallel bed overlain by 30° crossbed at non-flot bedding contact

Rocks at Outcrop 4 are thick-bedded and are loaded with planar cross bedding and horizontal planar bedding

3.2.1.1 Discussion on Sedimentary Logging

According to Lee (2006), Chinchin member which is where Tengkorak Bed is categorized in, has characteristic of fining upward succession. However, in this paper, Pasir Tengkorak beach's outcrops are observed to be coarsening upward succession as a whole. This is because the general fining upwards of the whole Tengkorak Bed is due to the reduction of clastic input as the hinterland or source area was peneplaned as published in Cambrian of Malaysia by Lee (2006). This means that while the individual sections are coarsening upwards as is seen in the log sections (due to it being deltaic), the overall sequence became finer as it approached the Machinchang-Setul transition where clastic input was reduced so that carbonate deposition could take over.

Further detailed discussions:

Outcrop 1

Figure 5: Picture of Outcrop 1.

Outcrop 1 (5m thickness) as a whole is a classic example of ***coarsening upward succession*** with mudstone and siltstone interbedding at the bottom of the sequence followed by thicker beds of sandstones with occasional interlayering with thin beds of

siltstones. During field visit, attempts to identify the grain size yield very fine to fine sandstone result. Rocks here are exposed in such a manner whereby the bottom part shows very gentle to no tilting while the upper part is slightly tilted (strike/dip: 283º/10º). Few things are recorded here including a sedimentary structure called load cast where it is seen at the base of one the beddings here. The sandstone bed seems to push a very thin layer of siltstone downward as it gets deposited. This feature is an important structure as it can help determine the younging direction of the whole bed.

Aside from that, there is another unique sedimentary structure found in Outcrop 1. It is called tafone. Tafone is a small cave-like feature where it is affected by a process called salt dessication or honeycomb weathering. Theoretically, salt is deposited on the surface of the rock by saltwater. The salt solution (sea water) then evaporates, leaving behind salt mineral within the pore spaces of the rock. These salt crystals pry apart the mineral grains, causing it to be vulnerable to other forms of weathering. Furthermore, there is also a soft-sediment deformation observed in this outcrop where thin lenses of sandstone get suspended within mudstone. Further details will be discussed in Outcrop 3 section.

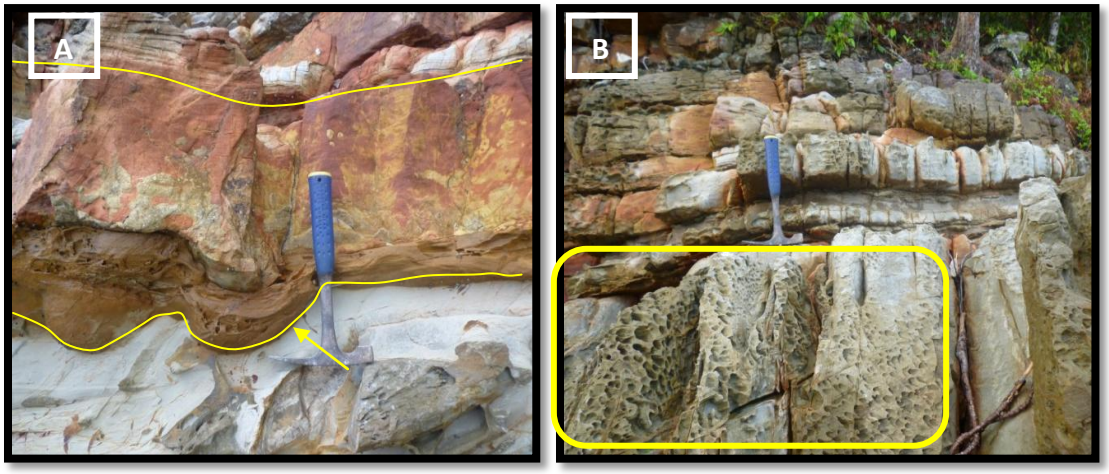


Figure 6: Picture (A) shows load cast at the bottom of sandstone bed. Picture (B) shows tefoni structure on rock surface.

Outcrop 2

Figure 7: Figure shows Outcrop 2 in Pasir Tengkorak beach.

Outcrop 2 (5m thickness) is dominated by mainly medium-thick to thick beds of blocky sandstone. It has relatively steeper dipping angle as compared to Outcrop 1 with (strike/dip: 300º/19º). There is little to no sedimentary structures observed in this outcrop. Attempts to identify the sandstone grain size yield result of very fine to fine and it shows ***coarsening upward succession*** in terms of bedding thickness, grain size and sediment input.

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Outcrop 3

Figure 8: Outcrop 3 has wavy-like bedding structure.

Outcrop 3 (5.3m thickness) has a very interesting bedding structure as it shows plastic deformation or wavy-like. The surface contacts between these very fine to fine grain-sized beds are undulating, different from the other outcrops in Pasir Tengkorak beach. The outcrop seems to be having two episodes of sandstone-siltstone interbedding. In addition, it should be noted that this outcrop has two siltstone beds where there are thin lenses of sandstone suspended within the bed, as is the case in Outcrop 1. The outcrop has ***coarsening upward succession*** and has complex strike and dip reading but averagely it has (strike/dip: 92º/50º and 170º/40º).

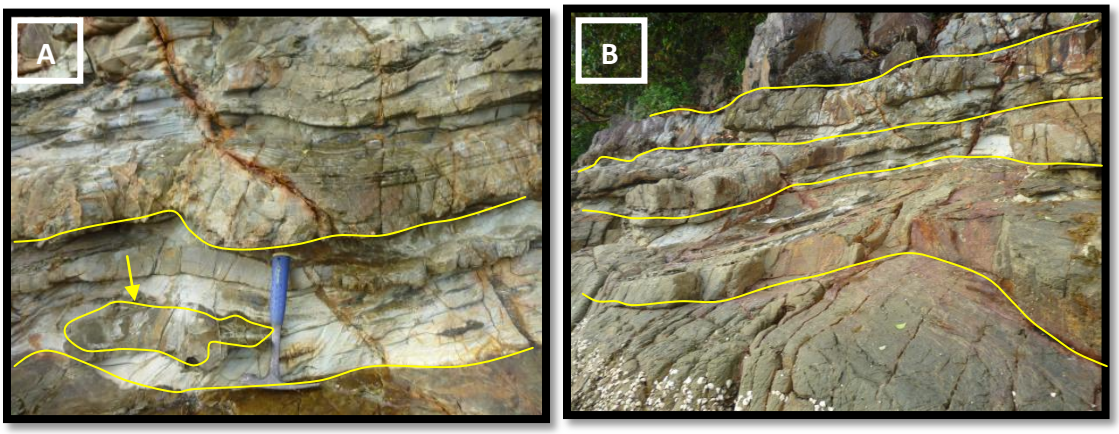


Figure 9: (A) shows the lense of sandy silstone suspended in mudstone. (B) shows wavy-like bedding.

Outcrop 4

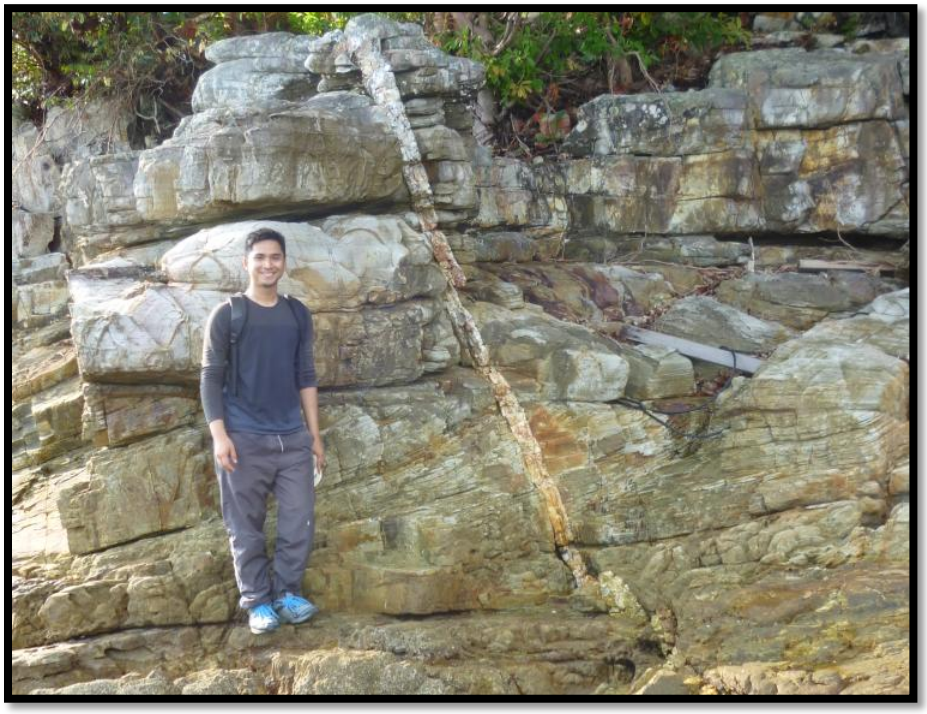


Figure 10: Outcrop 4 has abundant planar cross-bedding.

Outcrop 4 (6m thickness) stands out from the rest of the outcrops as having abundant horizontal planar bedding and planar cross bedding. It is fine grain size and has ***coarsening upward succession*** in terms of grain size and sediment input. Pictured above is a big quartz vein or rather quartz dyke cutting across the beds. Aside from these interesting structures, it also has interesting joint systems and sea cave. The geology is mainly made up of (strike/dip: 87º/2º).

Figure 11: (A) show jointing system. (B) shows seas-cave that is developing at Outcrop 4.

Facies Type

Based on the logging, five facies types were identified. Generally, facies types are classified based on five characteristics which are lithology, paleocurrent, sedimentary structure, geometry, fossils/trace fossils. However, in this paper, no fossils were found in the outcrop leaving the rocks to be classified based on only four factors.

Facies	Outcrop	Sedimentary structures	Sedimentary environment
1) Blocky sandstone		Fine to medium grain size, no apparent lamination, thick bed	River mouth
2) Planar cross-bedded sandstone		Fine grain size, medium size bed	Distributory channel
3) Horizontal planar-bedded sandstone		Very fine-fine grain size, medium-size bed	Proximal delta front
4) Siltstone		Intermediate between mudstone and sandstone, slightly coarser than mudstone but finer than sandstone	Upper Prodelta
5) Mudstone		Clay sediments, thin bed, powdery grain.	Lower prodelta,

Facies succession

Lee (2006) in his paper concluded that Tengkorak Bed is of a fining upward rock succession. However, the sedimentary logging done in this paper shows that the Tengkorak Bed found in Tengkorak Beach seems to be a coarsening upward succession. When confronted with this finding, Dr. Lee in an interview has explained that the Tengkorak Bed in his paper entitle "The Cambrian of Malaysia" has a wider extension covering from Tengkorak Beach up to Pulau Jemuruk. In another words, this paper only covers a small part of Tengkorak Bed than that of Lee's paper.

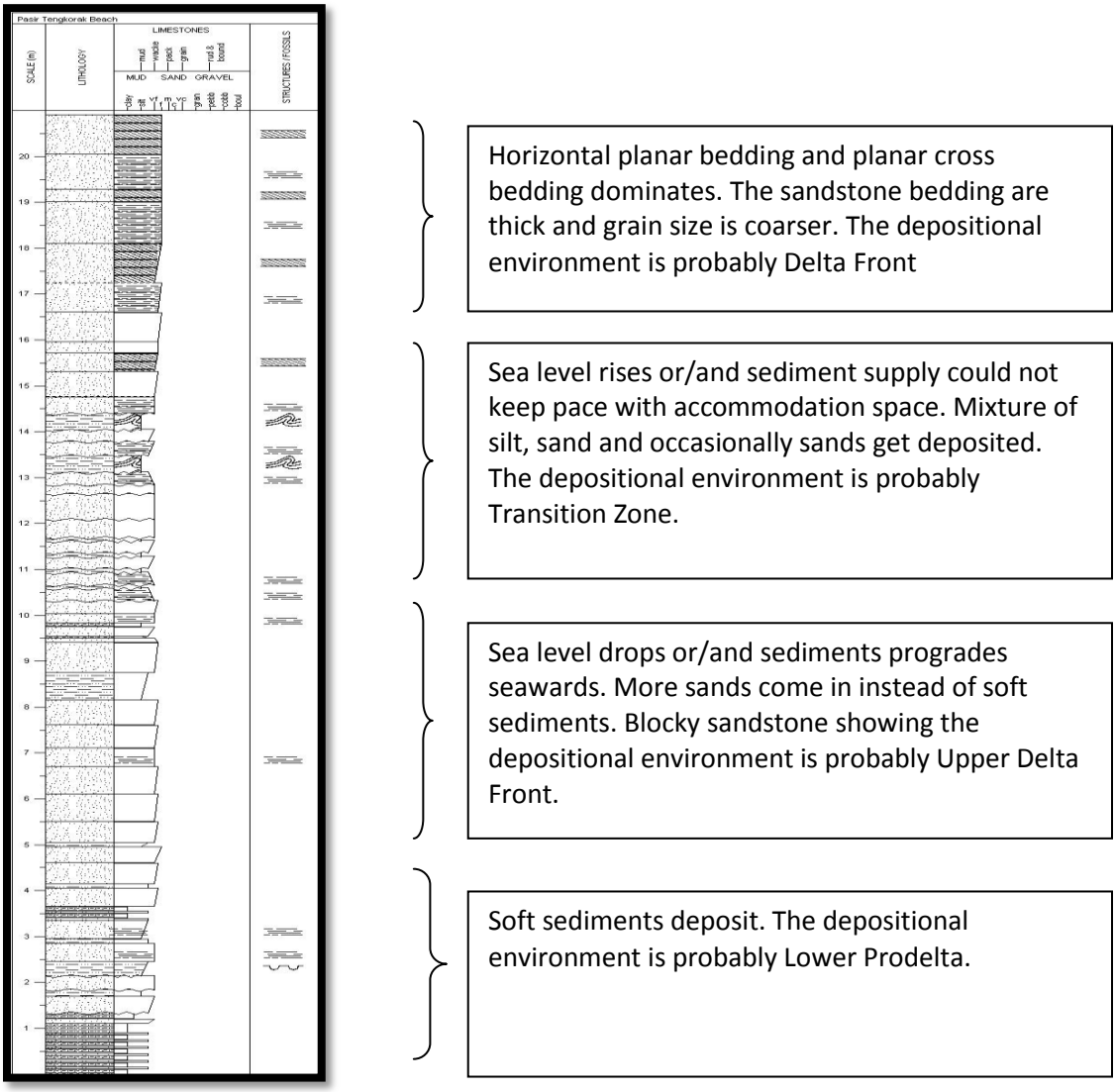


Figure 12: Figure shows condensed sedimentary log of outcrops in Pasir Tengkorak beach.

Depositional Model

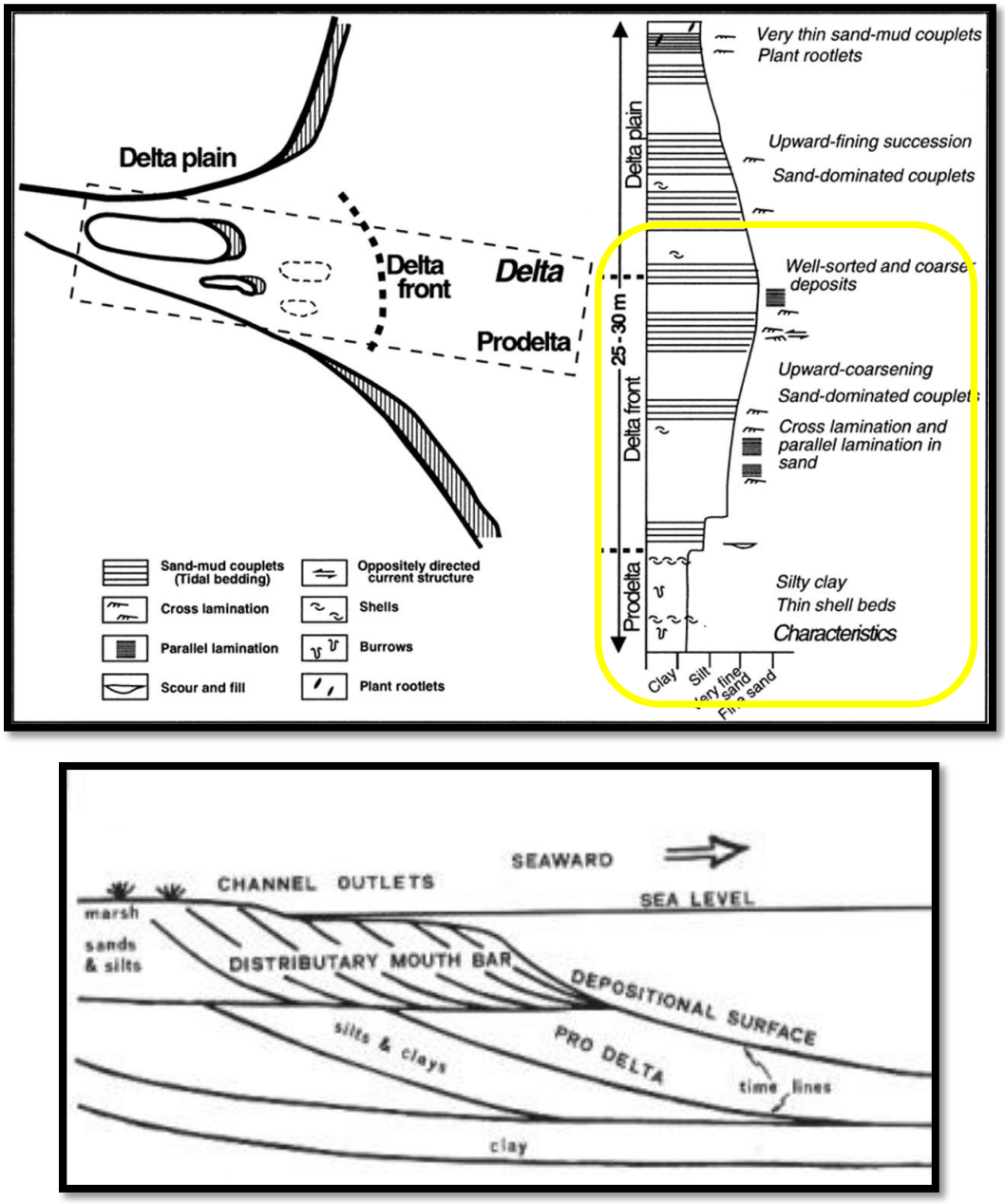


Figure 13: Figure shows the suggested depositional model of outcrops in Pasir Tengkorak beach.

Based on the interpretation from the sedimentary logs, it is found that the depositional environment of the outcrops found in Pasir Tengkorak beach is deltaic, specifically delta front and prodelta environment. Generally, current flow decreases from delta

Mudstone facies

The mudstone facies found mainly in outcrop 1 which has thickness of about 1.5m tells that the flow current is weak. When the current is weak, fine and soft sediments such as clay and silt get suspended and eventually settled down. The color of mudstone beds here is generally grayish white.

Siltstone facies

Siltstone facies can be found mainly in Outcrop 3 although there is also siltstone deposition at other outcrops too. The siltstone beds here are generally greenish-grey in color and it has coarser grain size than mudstone.

Horizontal planar-bedded sandstone facies

This facies is thought to be deposited in delta front where sand sediment settles down in lower delta front. As more sediment comes in, according to Principle of Horizontality, the spread laterally and gets stacked as accommodation space increases. The current in delta front is stronger than prodelta thus less or no soft sediment settles down.

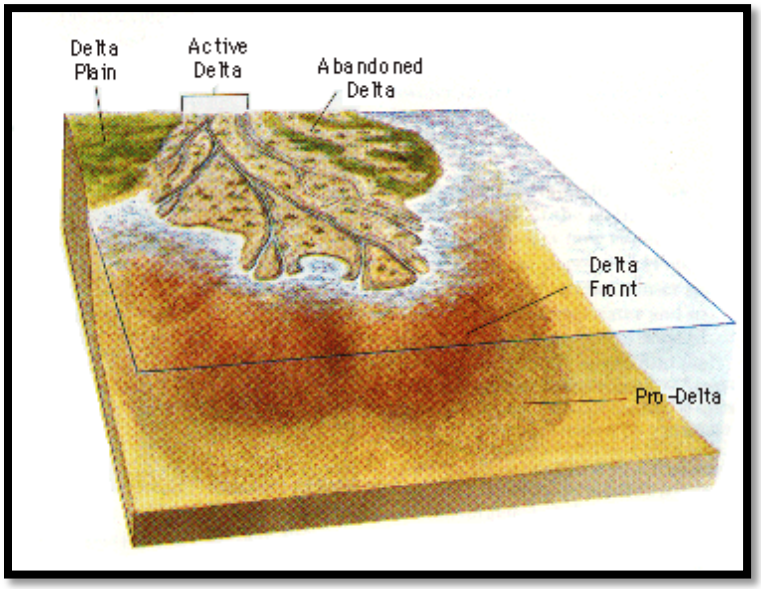


Figure 14: Figure shows the depositional environment for horizontal planar-bedded sandstone.

Planar cross-bedded sandstone facies

This facies is also has delta front as depositional environment. However, probably due to it being deposited in slopy setting, cross bedding forms.

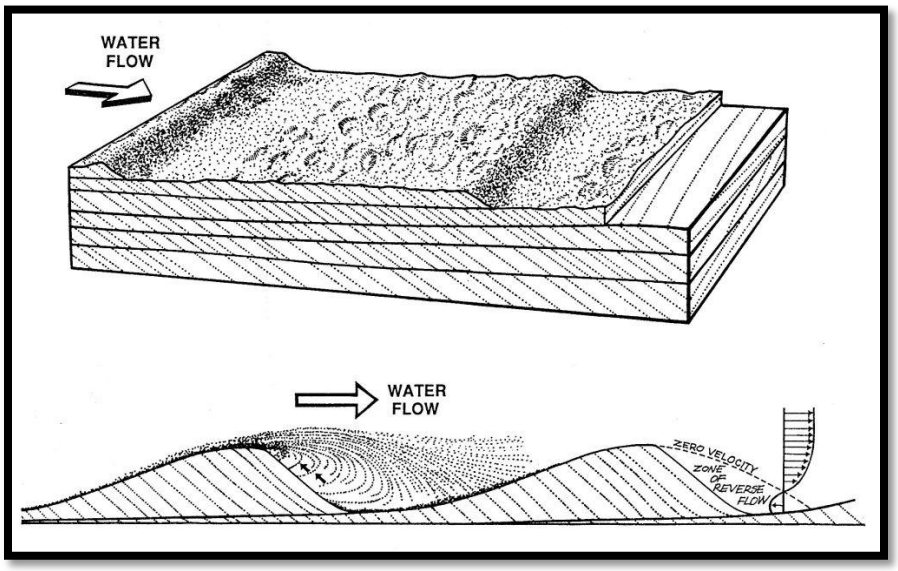


Figure 15: Figure shows how crossbedding forms

Blocky sandstone facies

This facies has fine grain size sediment and has thick bedding. It has no apparent lamination and the depositional environment is probably at the river mouth where current is strongest among other facies in this paper.

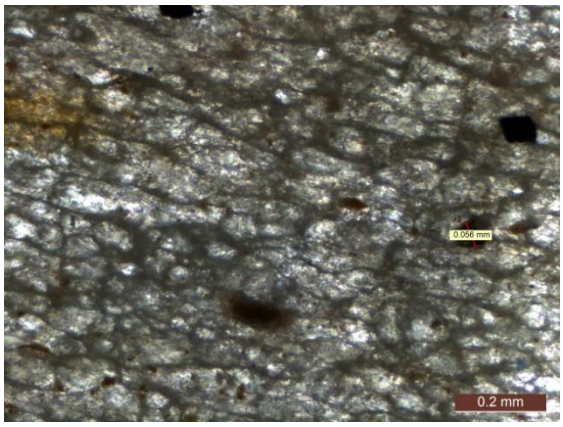
3.2.2.2. Petrographic Study

During the site visit, samples of unidentified or various rocks are taken to be further analyzed to be observed under thin section. This method is called petrography where the mineral content, grain size and the textural relationships within the rock are described in detail. These detailed analyses of minerals by optical mineralogy in this section are critical in order to understand the origin of the rock.

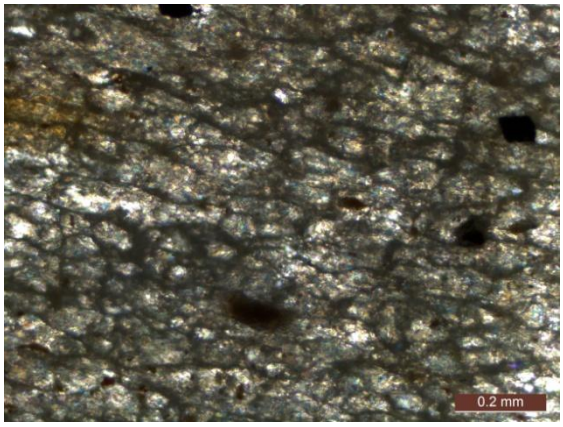
Thin sections

Minerals were observed under microscope with different light exposures and polarities. Thin section number is applied according to sample numberings. The magnification is set at 10x.

1) **Sample 1: Very fine quartzite sandstone**



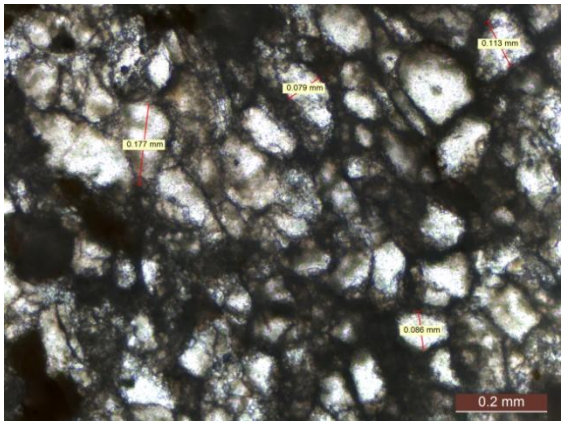
PPL



XPL

- Grain size= mostly 0.10mm – 0.06mm indicating very fine quartz
- Minerals = quartz and lots of iron oxide and clay
- Sorting = well sorted
- Roundness= subangular

2) Sample 2: Very fine quartzite sandstone



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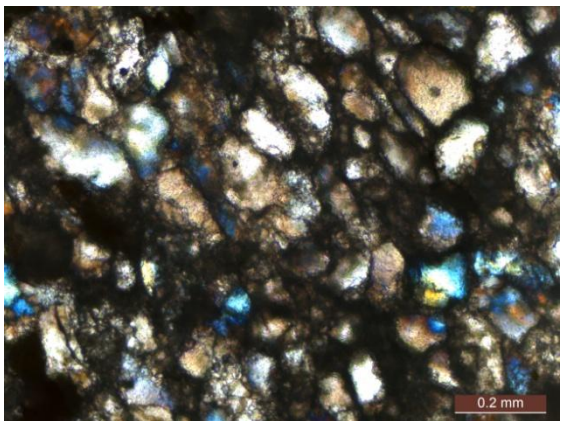
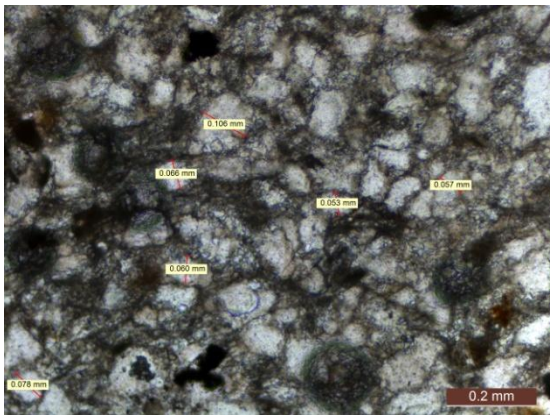


XPL

- Grain size = very fine to fine quartz grain in between 0.18mm – 0.08mm
- Minerals = mostly quartz with iron some iron oxide.
- Sorting = medium sorted. Grains are mostly of similar size.
- Roundness = subangular

3) Sample 3: Very fine to fine quartzite sandstone



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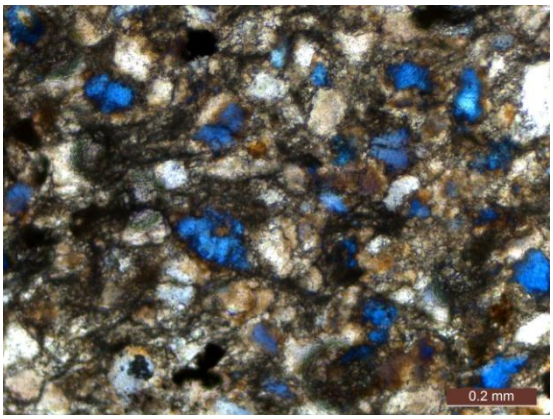
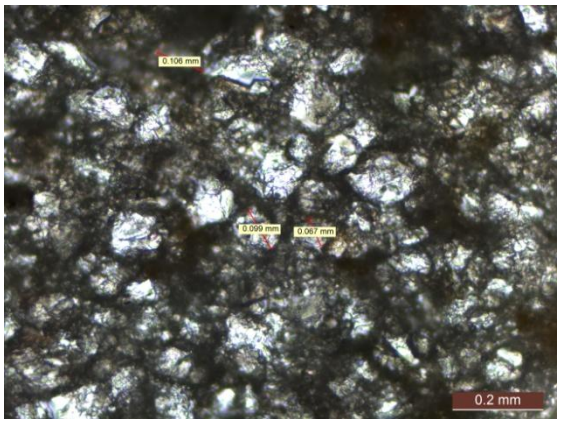


XPL

- Grain size= ranging from the largest 0.1mm to smallest 0.05m with most of the quartz grains have size <0.12 which falls under very fine sand.
- Minerals= mostly quartz and rare occurrence of iron oxide
- Sorting= medium sorted
- Roundness= subangular

4) Sample 4: Very fine quartzite sandstone



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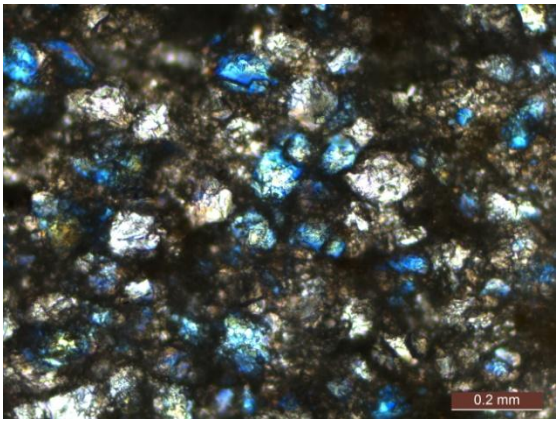
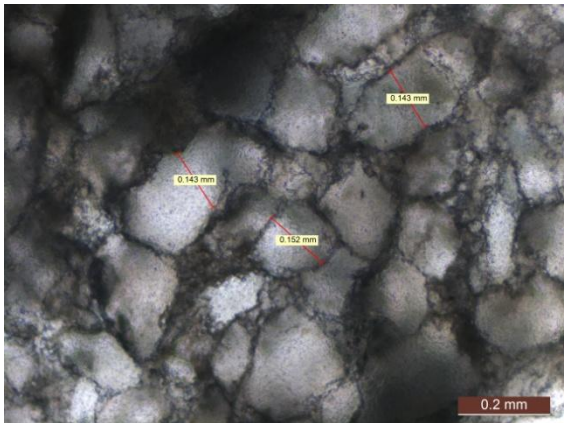


XPL

- Grain size = ranging from the largest 0.106mm to smallest 0.006m with most of the grains have size <0.05mm which falls under very fine to fine sand.
- Minerals = quartz, iron oxide
- Sorting = medium sorted
- Roundness = subangular

5) Sample 5: Fine to medium quartzite sandstone



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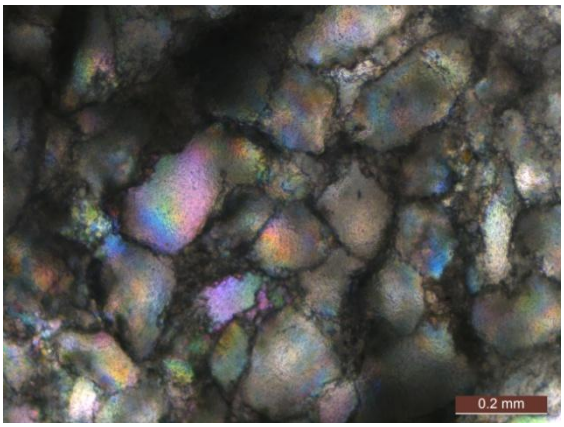
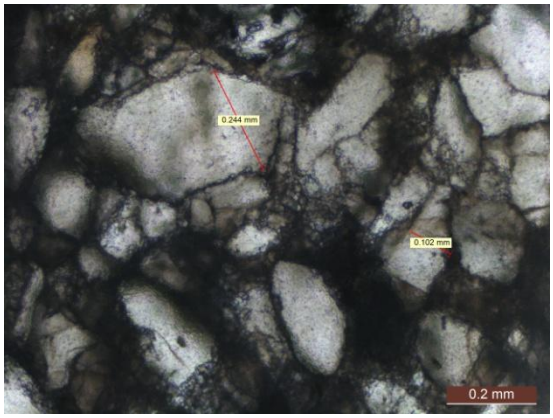


XPL

- Grain size= ranging from the largest 0.15mm to smallest 0.143m with most of the grains have size about 0.15 which falls under fine sand
- Minerals= mainly quartz and some iron oxide
- Sorting = medium sorted
- Roundness = subangular

6) Sample 6: Medium grain size quartzite sandstone



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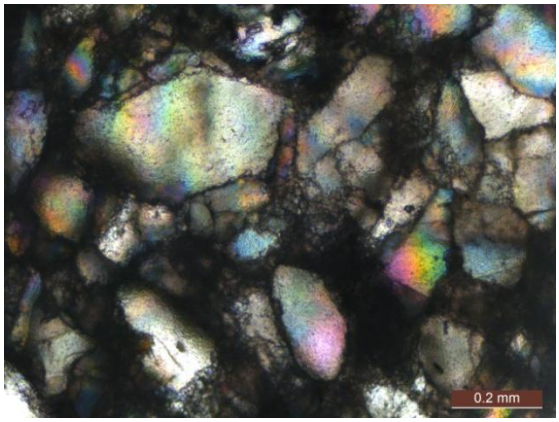
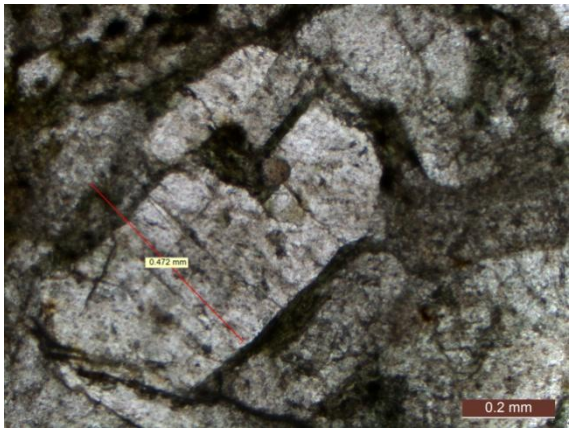


XPL

- Grain size= ranging from the largest 0.25mm to smallest 0.102m with most of the grains have size about 0.20mm which falls under fine to medium sand
- Minerals= mainly quartz and very rare occurrence of iron oxide
- Sorting = poorly sorted
- Roundness = subangular

7) Sample 7: Medium grain size quartzite sandstone



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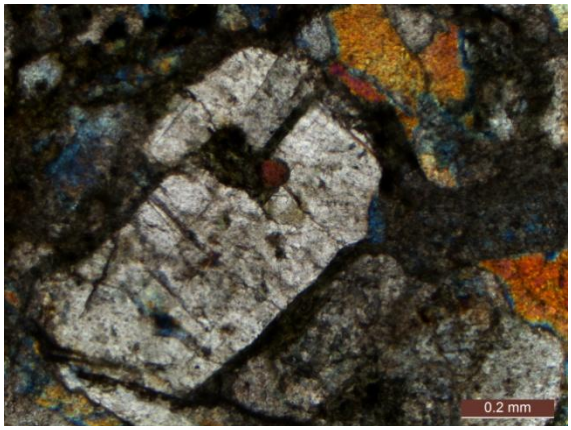


XPL

- Grain size= ranging from the largest 0.40mm to smallest 0.20mm with most of the grains have size about 0.30mm which falls under very fine sand
- Minerals= mainly quartz and some biotite
- Sorting = well sorted
- Roundness = subangular

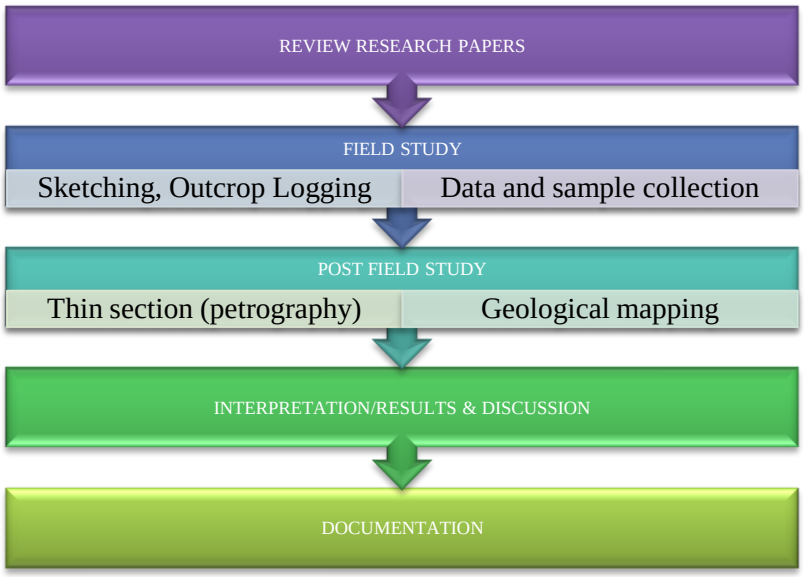
Discussion and Analysis of Minerals under Thin Section

Seven samples from Langkawi were brought back and examined under microscope. All of the samples are of sandstone. The aim is to study the grain size together with mineral identification. Below is the breakdown of grain size of sample number 1 to sample number 7.

Sample number	Grain size
1	Very fine
2	Very fine
3	Very fine
4	Very fine to fine
5	Fine to medium
6	Medium
7	Medium

The result shows that samples that were brought back to be examined have grain size ranging from medium to very fine sand. This finding is consistent with finding from Lee (2006) where he pointed out that the top of Tengkorak Bed is dominated by fine to very fine thick bedded sandstone facies.

2.2 Key Milestones

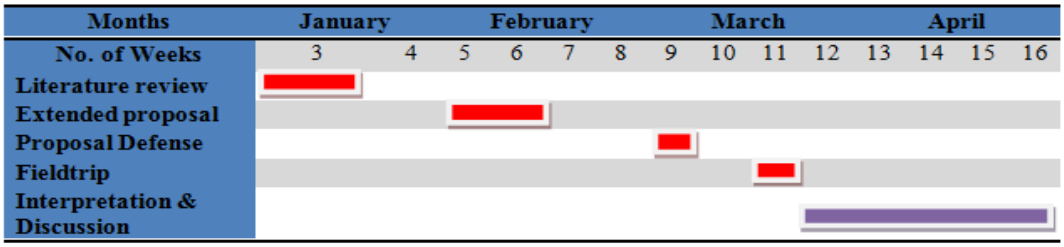


The above are the steps and processes laid out for a smooth and effective project execution. Finding information, collecting relevant data and looking for research papers are among the most vital processes and it was done at the very beginning of this project. Journals and published papers that focus on Machinchang Formation were obtained and studied in order to understand the background and details of Tengkorak Beds specifically and Machinchang Formation generally. After that, two field trip studies had been carried out to investigate further and put the central focus on the main interest, which is to find out the general geology and sedimentology of outcrops found in Pasir Tengkorak area. Essentially, outcrop sketching, logging, rock sampling and other important data were assembled to be used for the next process which is lab analysis and interpretation.

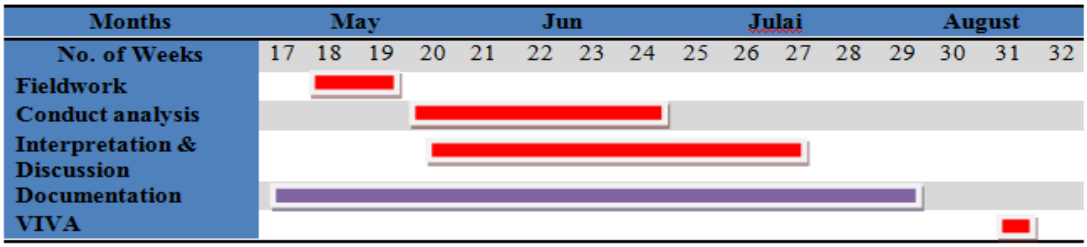
Seven rock samples were prepared for thin section analysis and the results are shown in the results and discussion section. Aside from that, geological mapping has also been drawn to document the geological features and information that could help in interpreting and understanding the project more. Documentation follows and all information and findings are recorded for academical purposes.

2.3 Gantt chart of Project Timeline

- FYP I



- FYP II



Remarks:

For Final Year Project I:

1. Dateline for project title selection: 22/01/2014
2. Dateline for Extended Proposal submission to SV: 26/03/2014
3. Dateline for Proposal Defense Presentation: 12/03/2014
4. Dateline for submission of Interim Draft Report to SV: 01/07/2014
5. Dateline for Pre- SEDEX presentation: 17/07/2014. SEDEX: 24/07/2014
6. Dateline for submission of Project Dissertation (Hard Bound) to coordinator with compilation of VIVA presentation, Technical Paper and Dissertation burnt to CD.

CHAPTER 4: CONCLUSION AND RECOMMENDATION

Machinchang Formation is a predominantly quartzose formation deposited in a shallow marine deltaic setting during late Cambrian time The objective of this research is to integrate and verify the paleoenvironment and stratigraphic sequence of Tengkorak Bed of Machinchang Formation at Pasir Tengkorak Beach by implementing sedimentology studies and analysis. The bed is classified into facies types based on characteristics such as lithology, paleocurrent, geometry and sedimentary structure. In this project, no fossils were found at the outcrop.

- Five facies types have been identified which are: horizontal planar bedded sandstone, planar cross bedded sandstone, blocky sandstone, siltstone and mudstone.
- Sedimentary logging was done and the result show coarsening upward succession and is sandier towards the top.
- The texture of sandstone in this outcrop is texturally and mineralogically very mature quartzerenite as sandstone dominates about 90% of minerals under thin section.
- The paleocurrent of the outcrop is thought to vary during the course of deposition. Generally it has bimodal and polymodal paleocurrent at different parts of the outcrop.
- The depositional environment of outcrops in Pasir Tengkorak beach is thought to be deltaic ranging from river mouth to lower prodelta.
- Geological map was drawn to aid in understanding the lithology and structural geology of the outcrop

Overall, the outcrop in Tengkorak Beach is found to be more typical of a deltaic environment.

As for recommendation, more detailed analysis needs to be done for Tengkorak Bed especially on the upper section as there is little research done on that part.

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